Thesis for licentiate degree
2020

Sickness absence and disability pension among individuals injured in a bicycle crash

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Stockholm 2020

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Published by Karolinska Institutet.
Printed by Eprint AB 2020

ISBN 978-91-7831-813-1

SICKNESS ABSENCE AND DISABILITY PENSION AMOUNG INDIVIDUALS INJURES IN A BICYCLE CRASH

THESIS FOR LICENCIATE DEGREE

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ABSTRACT

Bicyclists are the road user group with the highest number of severe injuries, yet little is known about the impact of such injuries on sickness absence (SA) and disability pension (DP). Therefore, the aim was to increase the knowledge on factors associated with SA and DP among individuals of working ages, injured in a bicycle crash.

Two register-based studies were conducted, including all individuals of working age and living in Sweden, who in 2010 had in- or specialized out-patient healthcare for injuries sustained in a new bicycle crash. The individuals where categorized by age, sex, crash type, type of injury, and injured body region. Study I, analyzed SA and DP at the time of the crash, the following groups were used: No new SA, Ongoing SA or full-time DP, and New SA spells >14 days. Logistic regression was used to estimate odds ratios (OR) and 95% confidence intervals (CI) for New SA spells >14 days, among those at risk of SA. In Study II, weekly SA/DP data for one year before and through three years after the crash date were used in sequence and cluster analyses. Multinomial logistic regression was used to estimate OR and 95% CI for factors associated with each sequence cluster.

In Study I, a total of 7643 individuals aged 16-64 years, had specialized healthcare due to a new bicycle crash in 2010, of which the majority (85%) were single-bicycle crashes. Among all, 10% were already on SA or full-time DP at the time of the crash, while 18% had a new SA spell. The most common types of injuries were external injuries (38%) and fractures (37%). The body region most frequently injured was the upper extremities (43%). The OR for New SA was higher for women compared to men (OR 1.40; 95% CI 1.23-1.58) and for higher ages compared to younger (OR 2.50; 2.02-3.09, for ages: 55-64 vs. 25-34). Fractures and internal injuries were the type of injury with the highest OR for New SA compared with external injuries (8.04; 6.62-9.77 and 7.34; 3.67-14.66, respectively). The body regions with the highest ORs for New SA, compared with injuries to the ‘head, face, and neck, not traumatic brain injury’ were injuries to the ‘spine and back’ (3.53; 2.24-5.55) and ‘traumatic brain injury, not concussion’ (2.72; 1.19-6.22).

In Study II, including 6353 individuals aged 18-59 years, injured in a bicycle crash 2010, and alive and living in Sweden during the whole follow-up, seven clusters were identified and named: "No SA or DP" (58.2% of all), "Low SA or DP" (7.4%), "Immediate SA" (20.3%), "Episodic SA" (5.9%), "Long-term SA" (1.7%), "Ongoing part-time DP" (1.7%), and "Ongoing full-time DP" (4.8%). Compared to the reference cluster, "No SA or DP", all other clusters were associated with a higher proportion of women, individuals of older age, and individuals who had only high school education (compared to university/college). Further, inpatient healthcare had high OR for all clusters but "Low SA or DP" compared with the cluster “No SA or DP”.

There were three clusters with different levels of SA. The clusters "Immediate SA" and "Episodic SA" had higher OR for fractures and injuries to the ‘spine and back’, the clusters "Episodic SA" and “Long-term SA” had higher OR for ‘traumatic brain injury, not concussion’, and the cluster “Long-term SA” had also higher OR for collisions with motor vehicles compared with the cluster “No SA or DP”.

Bicycling is an important part of a sustainable transportation system, but is not risk-free. Among individuals of working age who in 2010 had incident in- or specialized out-patient healthcare for injuries sustained in a bicycle crash, 18% had a new SA spell in connection to the crash. Seven clusters of SA and DP sequences were identified displaying that sequence analysis enabled exploration of different characteristics across different patterns of SA and DP following a bicycle crash.

SVENSK SAMMANFATTNING

Bakgrund: Cyklister är den trafikantgrupp med högst antal allvarligt skadade personer. Dock är kunskapen om deras sjukskrivning och sjuk- och aktivitetsersättning (tidigare förtidspension) i samband med cykelolyckan mycket begränsad. Avhandlingens syfte var att studera sjukskrivning och sjuk- och aktivitetsersättning bland skadade cyklister dels i samband med cykelolyckan och dels på längre sikt.

Metod: Två studier genomfördes baserade på registerdata för de personer i arbetsför ålder i Sverige som 2010 hade slutenvård eller specialiserad öppenvård för personskador från en cykelolycka. Faktorer som studerades var bland annat kön, ålder, utbildningsnivå, typ av cykelolycka, typ av personskada och skadad kroppsregion. Studie I analyserade sjukskrivning i samband med olyckstillfället, tre grupper användes: ’ingen sjukskrivning, sjuk- eller aktivitetsersättning’, ’pågående sjukskrivning eller heltid sjuk- eller aktivitetsersättning’ och ’ny sjukskrivning >14 dagar’. Logistisk regression användes för att beräkna oddskvoter (OR) och 95 % konfidens intervall (KI) för ny sjukskrivning för de som inte redan hade pågående sjukskrivning eller heltids sjuk- eller aktivitetsersättning. I Studie II användes veckovisa data för sjukskrivning och/eller sjuk- och aktivitetsersättning under ett år före och tre år efter cykelolyckan i sekvens- och klusteranalys. Multinomial logistisk regression användes för att beräkna OR och 95 % KI för faktorer associerade med vart och ett av de identifierade klustren.

Resultat: Totalt hade 7643 personer i åldrarna 16-64 år slutenvård eller specialiserad öppenvård för personskador på grund av en ny cykelolycka 2010. De flesta (85 %) skadades i singelolyckor. Totalt var 10 % redan sjukskrivna eller hade sjuk- eller aktivitetsersättning på heltid vid olyckstillfället, medan 18 % påbörjade ett nytt sjukskrivningsfall > 14 dagar i samband med cykelolyckan. De vanligaste typerna av skador var utvärtes skador (38 %) och frakturer (37 %). Den kroppsregion som oftast skadades var arm (43 %). Det var högre sannolikhet för ny sjukskrivning för kvinnor jämfört med män (OR 1,40; 95 % KI 1,23 - 1,58) och för äldre jämfört med yngre (OR 2,50; 95 % KI 2,02 - 3,09, för åldrarna: 55-64 år jämfört med 25-34 år). Frakturer hade ungefär 8 gånger högre sannolikhet för ny sjukskrivning och invärtes skador hade ungefär 7 gånger högre sannolikhet för ny sjukskrivning jämfört med utvärtes skador (OR 8,04; 95 % KI 6,62 - 9,77 respektive OR 7,34; 95 % KI 3,67 - 14,66). Skador på ryggrad och ryggmärg (OR 3,53; 95 % KI 2,24 - 5,55) och traumatisk hjärnskada, ej hjärnskakning (OR 2,72; 95 % KI 1,19 - 6,22) hade högre sannolikhet för ny sjukskrivning jämfört med huvud-, ansikte- och nackskador, ej traumatisk hjärnskada.

I sekvens- och klusteranalysen i Studie II inkluderades de 6353 personerna som var i åldrarna 18-59 år och som levt i Sverige under hela studieperioden. Sju kluster identifierades: ”Ingen sjukskrivning/sjuk- och aktivitetsersättning”, ”Lite sjukskrivning/sjuk- och aktivitetsersättning”, ”Omedelbar sjukskrivning”, ”Episodisk sjukskrivning”, ”Långtidssjukskrivning”, ”Pågående deltids sjuk- eller aktivitetsersättning” och ”Pågående heltids sjuk- eller aktivitetsersättning”. Det största klustret var ”Ingen

sjukskrivning/sjuk- och aktivitetsersättning” (58 % av personerna). Jämfört med detta kluster var alla andra kluster associerade med att innehålla större andelar kvinnor, personer i övre åldersgruppen och personer med utbildning på gymnasienivå. I alla kluster förutom klustret ”Lite sjukskrivning/sjuk- och aktivitetsersättning” var det högre sannolikhet för slutenvård jämfört med klustret ”Ingen sjukskrivning/sjuk- och aktivitetsersättning”. Klustret ”Omedelbar sjukskrivning” karaktäriserades av sjukskrivning endast i samband med cykelolyckan. Detta kluster hade fyra gånger så hög sannolikhet för frakturer (OR 4,3; 95 % KI 3,5 - 5,2), och två gånger så hög sannolikhet för luxation (OR 2,8; 95 % KI 2,0 - 3,9) jämfört utvärtes skador. I klustret ”Episodisk sjukskrivning” hade merparten av personerna sjukskrivning vid cykelolyckan och kunde även ha ett eller flera kortare sjukskrivningsfall under uppföljningstiden. I detta kluster var det högre sannolikhet för traumatisk hjärnskada, ej hjärnskakning (OR 4,2; 95 % KI 1,1 - 16,1), skador i ryggrad och ryggmärg (OR 4,5; 95 % KI 2,2 - 9,5), torso (OR 2,5; 95 % KI 1,4 - 4,3), arm (OR 2,9; 95 % KI 1,9 - 4,5) och ben (3,5; 95 % KI 2,2 - 5,5), jämfört med huvud-, ansikte- och nackskador, ej traumatisk hjärnskada. I klustret ”Långtidssjukskrivning” hade personer sjukskriving under nästan hela uppföljningstiden och några personers sjukskrivning påbörjades redan innan cykelolyckan. Detta kluster hade högre sannolikhet för traumatisk hjärnskada, ej hjärnskakning (OR 18,4; 95 % KI 2,2 - 155,2) jämfört med andra huvud-, ansikte- och nackskador ej traumatisk hjärnskada.

Slutsatser: Cykling är en viktig, men dock inte riskfri, del av ett hållbart transportsystem. Bland personer i arbetsför ålder som under 2010 hade slutenvård eller specialiserad öppenvård efter en cykelolycka påbörjade 18 % en ny sjukskrivning i samband med cykelolyckan. Frakturer var vanligt förkommande vid kort sjukskrivning i samband med cykelolyckan. Traumatisk hjärnskada, ej hjärnskakning innebar högre sannolikhet för långvarig sjukskrivning. De stora variationerna i mönstret av sjukskrivning och sjuk- och aktivitetsersättning efter cykelolycksskada visar på heterogeniteten i detta.

LIST OF SCIENTIFIC PAPERS

I. Kjeldgård L, Ohlin M, Elrud R, Stigson H, Alexanderson K, Friberg E. Bicycle crashes and sickness absence - a population-based Swedish register study of all individuals of working ages. BMC Public Health 2019, 19(1):943.

II. Kjeldgård L, Stigson H, Alexanderson K, Friberg E. Sequence analyses of sickness absence and disability pension in the year before and the three years following a bicycle crash; a nationwide longitudinal cohort study of 6353 injured individuals. *Submitted.*

RELATED PUBLICATIONS

Ohlin M, Kjeldgård L, Elrud R, Stigson H, Alexanderson K, Friberg E. Duration of sickness absence following a bicycle crash, by injury type and injured body region: A nationwide register-based study. Journal of Transport and Health. 2018, 9:275-281.

Elrud R, Stigson H, Ohlin M, Alexanderson K, Kjeldgård L, Friberg E. Sickness absence among Passenger Car Occupants following a crash. International Research Council on Biomechanics of Injury (IRCOBI) Conference proceedings 2017; IRC-17-18:79-90

CONTENTS

LIST OF ABBREVIATIONS

CI	Confidence interval
DP	Disability pension
EU	European Union
ICD-10	International Classification of Diseases, version 10
LISA	Longitudinal Integration Database for Insurance and Labour Market Studies
MiDAS	Micro Data for Analysis of the Social insurance
OR	Odds ratio
SA	Sickness absence
TBI	Traumatic brain injury
UN	The United Nations
W_0	Week zero, the week of three days before and three days after the crash date

1 BACKGROUND

1.1 BICYCLING AS SUSTAINABLE TRANSPORTATION

Bicycling as a physical activity has a positive impact on public health and increased bicycling is also an important aspect of a sustainable transportation system[1, 2]. On the other hand, bicycling involves risks such as being involved in, and getting injured in bicycle crashes. In 2010, a decade of action for road safety was proclaimed by the United Nations (UN) General Assembly[3]. Road safety was in 2015 included in two of the targets of the UN 2030 Agenda for sustainable development[2], namely;

- 3.6: By 2020, halve the number of global deaths and injuries from road traffic accidents
- 11.2: By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons

The 3rd Global Ministerial Conference on Road Safety, held in Stockholm in the beginning of 2020, recognized that the target "3.6" was not met[4]. The outcome of this conference was the Stockholm Declaration, calling upon member states to continue reducing road deaths by at least 50% from 2020 to 2030 and to continue the action on road safety related sustainable development targets, including "3.6" also after 2020[5]. The recognition of these two targets places road safety at the same level as the other sustainability goals of the UN and indicates that sustainable health and well-being cannot be achieved without reducing deaths and serious injuries from road traffic[4]. In the area of traffic safety, the safety for bicyclists is one of the largest challenges[1]. Different stakeholders have lately given more attention to creating a safer road environment for bicyclists[6]. Two important reasons for this are that increased bicycling is an important complement to reduce vehicle congestion and greenhouse gas emissions[1] and a way of increasing physical activity in the population. The positive effects of physical activity on health is well-known as well as the recognition of physical inactivity as a major public health problem[7]. Several recent studies have highlighted the positive health effects of increased bicycling[8-10], both for the individuals themselves due to increased physical activity, and to the general population due to less exposure to air pollution[9].

1.2 BICYCLE INJURIES

Bicycling involves some risks for the bicyclists[1, 11], e.g., a recent study observed 29 times higher risk for injury and ten times higher risk of fatality among bicyclists compared with car occupants[12]. After an injury, both physical and mental health can be affected up to ten years after the injury[13]. In 1997, Vision Zero was adopted in Sweden, a road safety strategy with the long-term vision of no fatal or serious injuries within the road transport system[14-16]. In short, no one should die or suffer injuries that lead to non-acceptable loss of health in the road transport system[17]. As the work with road safety has progressed, the number of fatal and serious injuries have decreased, especially among car occupants[18]. Such attempts have not been as successful for bicyclists, actually, bicyclists are nowadays the road-user group with the highest number of severe injuries in Sweden as well as in all EU[18, 19]. This has led to more focus on bicyclists[20, 21].

Traditionally, information on road crash causalities is based mainly on police-reported death and severe injuries[22]. However, this may not adequately describe the situation since under-reporting of the number of crashes has been shown, especially among vulnerable road users[23]. In Sweden, only 7% of all bicycle crashes are covered in the police reports[24]. Another source could be healthcare register data, covering a much larger proportion of bicycle crashes[25], especially in Sweden were the validity of the Swedish National Inpatient Register is high[26, 27]. Furthermore, in Sweden most individuals seek healthcare if in need of it as all are covered with the universal public healthcare insurance, meaning that (you only pay a very small sum for healthcare) the cost for healthcare is minimal for the individual[28, 29].

1.3 SICKNESS ABSENCE AND DISABILITY PENSION AFTER A BICYCLE CRASH

A majority of the bicycle crash injuries are non-fatal but could lead to long-term consequences, hence, focus on non-fatal outcomes is essential[8]. One such consequence could be that the injury leads to reduced work capacity to such an extent that the injured individual might have to be on sickness absence (SA) or disability pension (DP). Sickness absence and DP does not only effect the individual but also the family, colleagues, employer, insurers, healthcare, and the society[30-32]. Therefore, SA and DP are possible consequences of bicycle crashes that need to be taken into consideration.

There is limited scientific knowledge about SA and DP after road traffic injuries. In the conducted studies so far, SA has been shown to be relatively common after a road traffic injury[33-38]. The scientific knowledge is even smaller regarding SA and DP after a bicycle crash, a field where only a few studies have been published[36-39]. Three of these studies are more than 20 years old and are based on relatively small samples (425-542 individuals)[36-38]. Furthermore, those three studies have not taken DP or ongoing SA at the time of the crash into consideration, that is, individuals not at risk of a New SA spell at the time of the crash. A more recent study is a large study that investigated duration of SA following a bicycle crash, including only individuals who were not already on SA or DP at the time of the crash[39]. This study found that a fifth had SA >14 days after a bicycle crash and that the duration of SA varied with type of injury and injured body region. There is a need for more nationwide studies based on healthcare data including all individuals involved in a bicycle crash were also those already on SA and DP are included and to investigate their long-term patterns of SA and DP.

1.3.1 Measures of sickness absence and disability pension

Sickness absence and DP can be measured in many different ways, and there is now more than one hundred different such measures in the litterature[40, 41]. Different units such as SA spells (e.g., new/ongoing/concluded, durations, extent (full- or part-time), and diagnoses), time (e.g., calendar days, working days, compensated days, and absent days), and individuals (e.g., number exposed, insured, in paid work, sick listed, and percentage sick listed), can be used and also combined in several different ways[40, 41]. A person can also have recurrent spells. In Sweden as in other countries, the distribution of the duration of SA spells is usually very skewed as most of the SA spells are short-terms spells[42, 43]. On the other hand, in Sweden those 2% of all SA spells that are longer than 90 days, contribute to about half of all SA days[42, 43], and are hence important to address. In addition, as both SA and DP can be granted for part-time, at least in the Nordic countries, some individuals have both SA and DP at the same time. Moreover, for some individuals the SA may end as DP. All these measures reveal the complexity of measuring SA and DP. Previously, mainly different types of traditional regression analyses have been used in analyses of risks regarding SA and DP and other such events[44, 45]. That is, focus has been on the outcome in a cross-sectional study, or at the end of follow-up in a longitudinal study. To gain knowledge on different patterns of SA and DP over time, during the whole follow-up time, not only at the end of follow-up, e.g., individuals' timing, duration, and order of different types of events, sequence analysis could be a suitable method[46]. Interest for such analyses has increased lately[47-49]. Several studies have performed sequence analyses, finding that the heterogeneity in the sequences can be a good complement and adding additional value to traditional regression analysis[48-50]. Thus, in order to get more knowledge of SA and DP in relation to a bicycle crash also in a long-term perspective, there is a need for studies using more comprehensive methods.

1.3.2 The Swedish public sickness absence insurance system

In the years studied here, all individuals living in Sweden, ≥16 years old, and with income from work, unemployment, or parental-leave benefits can get SA benefits if they have a disease or injury leading to reduced work capacity[51]. The first day of a SA spell is an unreimbursed qualifying day (varying number of days for self-employed). A physician's certificate is required from the eight day. For most employees, day 2-14 are reimbursed by the employer, thereafter, by the Social Insurance Agency. For others, e.g., unemployed, the Social Insurance Agency administrates benefits from the second SA day, thus, information also on shorter SA spells was available for those individuals. In this thesis, in order not to introduce a bias, only SA spells >14 days were included. All individuals aged 19-64 can be granted DP if their disease or injury leads to long-term or permanent work incapacity. The public benefits for SA cover 80% of lost income up to a certain level, and for DP 64% of lost income up to a certain level. Both SA and DP can be granted for full- or part-time (100, 75, 50, 25%) of ordinary work hours. That is, someone on part-time DP can at the same time have part-time SA.

1.3.3 Factors associated with sickness absence and disability pension

Several previous studies have shown associations between different sociodemographic factors and SA[31, 44, 52-55]. A systematic review summarized that women, individuals in higher age groups, and individuals with lower socio-economic status have higher probability for

SA[52]. Individuals' level of education is often used as a proxy for socio-economic status instead of, e.g., level of income or type of occupation. Generally, higher education is associated with lower levels of SA[56]. Also country of birth, type of living area, and marital status have been shown to be associated with SA and DP[57, 58]. Further, previous SA and DP have been reported to be associated with future SA[55, 59, 60] as well as with future DP[57, 58].

For individuals injured in a bicycle crash, the knowledge on associations of sociodemographic factors with SA and DP is limited. Ohlin et al, showed that several sociodemographic factors (sex, age, level of education, and country of birth) were associated with the duration of SA following a bicycle crash[39]. A Finnish study on bicycle crashes and SA showed an age-related trend, where the mean duration of self-reported work disability increased with age[38].

1.4 INSURANCE MEDICINE RESEARCH

The research within this thesis was conducted within the area of insurance medicine research. Sickness absence and DP can be studied in several ways, using different design, data, analysis methods, etc[61]. A categorization of this is presented in Table 1, and the aspects relevant to this thesis are in the table marked in bold text.

Table 1. Categorizations of the performed studies in this thesis according to a structure for categorization of studies on sickness absence and disability pension[61]. The factors relevant for this thesis are marked in bold.

What is studied	-Design -Data -Analyses	Scientific discipline	Perspective taken in the research questions	Studied	Structural level of the factors included in the analyses	Diagnoses
Factors that hinder or promote SA/DP Factors that hinder or promote return to work "Consequences" of (being on) SA/DP Sickness certification practice Methods, theories	*Study design:* **Cross sectional** **Longitudinal** Randomized controlled trial, Clinical trial, etc. *Type of data:* Interview Questionnaire **Register** Medical files Insurance files Certificates Documents Video Other *Type of analyses:* Qualitative **Quantitative**	Economy Law Management Medicine Psychology Sociology **Public health** **Epidemiology** Philosophy Other	**Society** Insurance Healthcare Employer Family Patient	General population Insured In paid work (general or special jobs/organization) Diagnosed Patients **Injured in bicycle crash** Sickness absent Organizations Professionals Countries	National Local Worksite Health care Family **Individual**	**All together** Mental Musculo-skeletal Cancer Circulatory Infections **Injuries** Other

2 AIM

The overall aim of this thesis was to increase the knowledge on factors associated with SA and DP among individuals of working ages, injured in a bicycle crash.

2.1 STUDY I

The aim of Study I was to explore SA and DP among individuals of working ages who were injured in a bicycle crash, both in general and by different sociodemographic factors, crash type, type of injury, and injured body region.

2.2 STUDY II

The aim of Study II was to identify long-term patterns of SA and DP among injured bicyclists and to explore factors associated with those specific patterns regarding crash and injury characteristics by adjusting for sociodemographic characteristics.

3 MATERIAL AND METHODS

Two register-based studies were conducted, the design, data, outcome, and analyses of these two studies are summarized below in Table 2.

Table 2. Overview of Study I and Study II

	Study I	**Study II**
Aim	To explore SA and DP among individuals of working ages who were injured in a bicycle crash, both in general and by different sociodemographic factors, crash type, type of injury, and injured body region	To identify long-term patterns of SA and DP among injured bicyclist and to find characteristics associated with the specific patterns
Design	Register based cross-sectional population-based study	Register-based longitudinal population-based cohort study with prospective and retrospective weekly measurements, during four years (one year before and through three years after a bicycle crash)
Data sources	LISA, National in- and specialized outpatient register, Cause of Death Register, MiDAS	LISA, National in- and specialized outpatient register, Cause of Death Register, MiDAS
Study population; N	7643 (16-64 years; 43.2% women)	6353 (18-59 years; 43.0% women)
Inclusion criteria	On 31 December 2009: living in Sweden, aged 16-64 years and receiving in- or specialized outpatient healthcare in 2010 due to injuries sustained in a bicycle crash, no transport-related injuries during three years prior to the inclusion date	On 31 December 2009: living in Sweden, aged 18-59 years. Receiving in- or specialized outpatient healthcare in 2010 due to injuries sustained in a bicycle crash, no transport-related injuries during three years prior to inclusion date. Alive and living in Sweden during the three years after the inclusion date
Outcome measures	No SA or DP, New SA, Ongoing SA or DP (regarding SA spells >14 days)	Clusters of sequences of weekly states on SA and DP during 4 years (regarding SA spells >14 days)
Factors included in the analyses	Sex, age, level of education, country of birth, type of living area, marital status, crash type, specialized healthcare, type of injury, injured body region	Sex, age, level of education, country of birth, type of living area, marital status, crash type, specialized healthcare, type of injury, injured body region
Statistical analyses	Descriptive statistics, logistic regression	Descriptive statistics, sequence analysis, cluster analysis, multinomial logistic regression

SA: Sickness absence, **DP**: Disability pension, **LISA**: Longitudinal Integration Database for Insurance and Labour Market Studies, **MiDAS**: Micro Data for Analysis of the Social insurance

3.1 DESIGN AND STUDY POPULATION

In Study I the population included all 5 982 221 individuals 16-64 years of age, living in Sweden 31 December 2009, who in 2010 received in- or specialized out-patient healthcare due to an injury from a new bicycle crash, n = 7643. In Study II the same cohort was used, however, restricted to those aged 18-59 years, as the cohort was studied one year before through three years after the bicycle crash, they all needed to be at risk for the outcomes SA and DP during the full study period. Further, those who died or emigrated during the three follow-up years were excluded, in order to have complete follow-up data for all included. A flowchart of the study populations is shown in Figure 1.

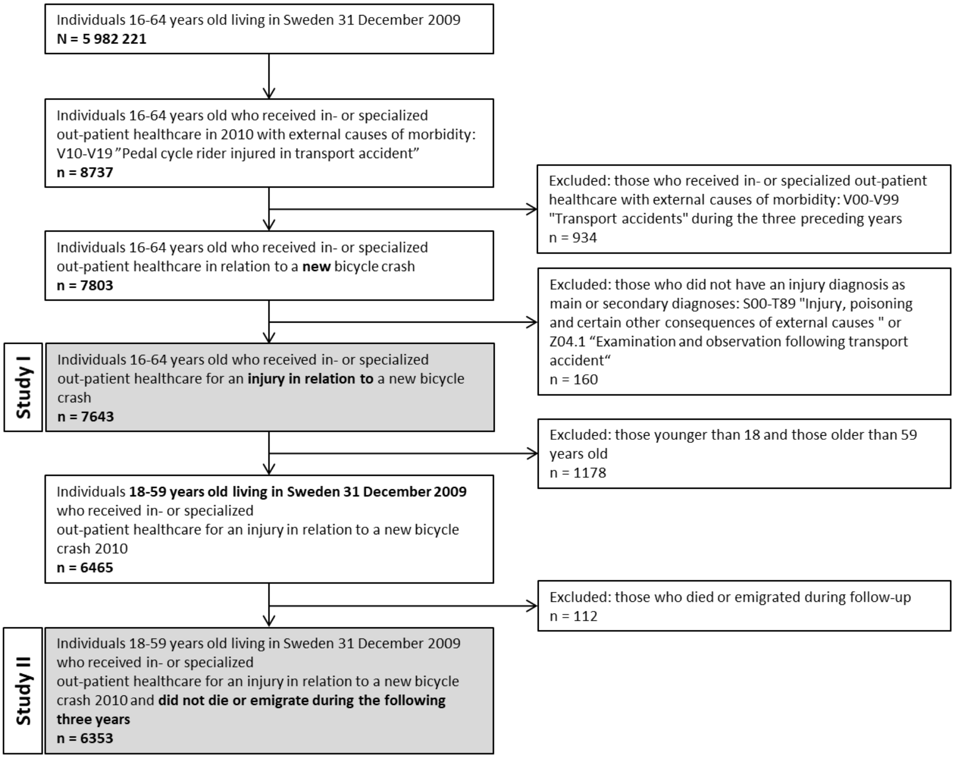

Figure 1. Flowchart of the study populations, inclusion criteria, and exclusion criteria for Study I and Study II.

3.2 DATA SOURCES

Both studies in this thesis were based on five Swedish nationwide registers administrated by Swedish authorities and linked on individual level by the use of the personal identity number assigned to all individuals resident in Sweden[62]. The different registers and their use in the thesis are below presented in more detail.

3.2.1 Longitudinal Integration Database for Insurance and Labour Market Studies (LISA)

The Longitudinal Integration Database for Insurance and Labour Market Studies (LISA) is kept by Statistics Sweden (SCB) and contains annual data on sociodemographic and social insurance measures for all individuals 16 year or older living in Sweden 31 December each year[63].

LISA was used to obtain sociodemographic factors at baseline; sex, age, level of education, type of living area, and marital status, as well as, to identify all individuals (Study I: aged 16-64, Study II: aged: 18-59) living in Sweden 31 December 2009.

3.2.2 The National Patient Registers

The National Patient Registers are kept by the National Board of Health and Welfare and include information regarding inpatient and specialized outpatient healthcare. They do not include information from primary healthcare. Regarding the aspects studied here, the registers have good coverage regarding the information needed; for inpatient healthcare 99% of the hospitalizations have a diagnosis and 98% of those that are due to injuries have a stated cause, corresponding numbers for specialized outpatient healthcare are 98% and 83%, respectively[64].

Information on all hospitalizations and all visits to specialized outpatient healthcare regarding dates, main diagnosis, secondary diagnoses, and external causes was obtained from the National Patient Registers. This information was used to identify all individuals who in 2010 had inpatient or specialized outpatient healthcare due to a bicycle crash, by identifying all visits/hospitalizations to inpatient and specialized outpatient healthcare with the external causes of morbidity International classification of Diseases, version 10 (ICD10)[65, 66]: V10-V19 “pedal cycle rider injured in transport accident”. The date of the first such visit/hospitalization for each individual was used as a proxy for the crash date, and will hereafter be refer to as the crash date. Further, to ensure incident injuries, e.g., that the registered healthcare in 2010 was not due to revisiting visits/hospitalizations following a previous accident, all individuals with any transport accident (ICD10: V00-V99) during the three years prior to their crash date were excluded. In addition, the diagnoses of the visit/hospitalization were used to ensure that the individuals actually had been injured. Those that did not have any injury diagnoses as their main or secondary diagnoses (ICD10: S00-T89 “Injury, poisoning and certain other consequences of external causes” or Z04.1 “Examination and observation following transport accident”) were excluded.

3.2.3 Micro Data for Analysis of the Social insurance (MiDAS)

The register Micro Data for Analysis of the Social insurance (MiDAS) is kept by the Social Insurance Agency and includes information on all spells and periods of SA and DP with benefits paid by the Social Insurance Agency.

Information on SA and DP (start and end dates, and extent (full- or part-time)) was obtained for Study I regarding the date of the bicycle crash and for Study II during one year before through three years after the bicycle crash.

3.2.4 The Cause of Death Register

The Cause of Death Register is held by the National Board of Health and Welfare and includes information on date and causes of death among all Swedish residents[67].

Information on date of death was obtained from this register and was used in Study I to identify those who died within 30 days after the bicycle crash and in Study II to exclude those who died during the three years following the bicycle crash.

3.3 EXPOSURE, COVARIATES, AND OUTCOME MEASURES

Information on the exposure, covariates and outcome measures used in the two studies are described below. All sociodemographic factors were obtained for the 31st of December of the year before the bicycle crash, i.e., 2009, and all crash- and injury related factors were obtained for the date of the crash.

3.3.1 Sociodemographic factors

All sociodemographic factors; sex, age, level of education, type of living area, and marital status were obtained the 31st December 2009 from LISA. Age was in Study I categorized into five groups: 16-24 years, 25-34 years, 35-44 years, 45-54 years, and 55-64 years old, and in Study II into two groups: 18-40 years old, and 41-59 years old. Level of education was categorized into three groups: elementary (≤9 years), high school (10-12 years), and university/college (>12 years). Country of birth was categorized as Sweden, and not Sweden. Type of living area was determined by population size of the municipality the individual lived in and categorized into the follow three groups: big cities (Stockholm, Göteborg, Malmö), medium-sized cities (with more than 90 000 inhabitants within 30 kilometer distance from center), and small cities/villages. Marital status was categorized as married, and not married (not married, divorced, and widowed).

3.3.2 Crash-related factors

Crash type was categorized into three groups using the ICD-10 code for external causes of morbidity: single-bicycle crash (ICD10: V17, V18, V19.3, V19.8, V19.9), collision with pedestrian, animal, or other bicycle (V10, V11), and collision with motor vehicle (V12-V16, V19, V19.1, V19.2, V19.4-V19.6). Single-bicycle crash includes crashes such as bicycle rider injured in a collision with fixed or stationary object, and non-collision transport accident (fall or thrown from bicycle). Further, bicycle riders injured in an unspecified accident were here categorized as single-bicycle crash.

3.3.3 Injury-related factors

3.3.3.1 Type of Injury and injured body region

Information on type of injury and injured body region was, as mentioned above, obtained for each visit/hospitalization in the inpatient and specialized outpatient healthcare register at the crash date. Each visit/hospitalization had a main diagnosis and could also have several secondary diagnoses. Moreover, some individuals had up to three visits/hospitalizations registered in the patient registers at the crash date. However, the majority, 78%, had only one injury diagnosis. For the individuals with several injury diagnoses, one injury diagnosis was selected in the following hierarchy: The main injury diagnosis was selected over secondary diagnoses, diagnoses for in-patient healthcare were selected over diagnoses for specialized outpatient healthcare, and injury diagnoses over other types of diagnoses (ICD10: S00-S99 over T00-T88, T00-T88 over Z04.1).

A modified version of the Barell matrix[68] was then used to categorize the diagnoses into

a) *type of injury*: fracture; dislocation; sprains and strains; internal (brain, spinal cord, and other internal organs); external (open wounds, contusions and superficial injuries); and other and unspecified, and
b) *injured body region*: 'all head and neck'; 'spine and back'; 'torso'; 'upper extremities'; 'lower extremities'; and 'other and unspecified'. The category 'all head and neck' were in most of the analyses divided into the three categories 'head, face and neck, not traumatic brain injury (TBI)'; 'TBI, not concussion', and 'concussion'. The categories of injured body region were the same in both studies, but in Study I they were named and ordered differently than in Study II. In this thesis, the categories are named and ordered as in Study II, i.e., according to the categorization just mentioned.

3.3.3.2 Healthcare

In Study I, healthcare at the crash date was categorized into the three following groups: only specialized out-patient healthcare, in-patient healthcare ≤1 day, and in-patient healthcare >1 day. The cut-off for in-patient healthcare was based on the median duration of hospitalizations among those hospitalized. In Study II, the variable was named inpatient healthcare and dichotomized into: no (only visits to specialized out-patient healthcare), and yes (in-patient healthcare at the crash date, may also have visits to specialized out-patient healthcare the same day).

3.3.4 Sickness absence and disability pension

Both studies included SA spells lasting >14 days and all DP spells. The individuals were identified through the date of the healthcare visit/hospitalization rather than the actual crash date, and hence, the healthcare visit/hospitalization and the start of SA does not necessarily take place at the same day. The distribution of SA start dates in relation to the date of the visit/hospitalization was taken into consideration when categorizing the SA and DP variables.

3.3.4.1 *Study I*

In Study I, a cross-sectional study, SA and DP at the time of the crash was categorized into the following three groups: Ongoing SA/DP, New SA, and No new SA. Ongoing SA/DP included individuals with DP on full-time with spells that had started before the crash date and were still ongoing, and individuals with SA spells (irrespective of the extent) that had started at least five days before the crash date and were still ongoing. New SA included individuals with SA spells that started on any day between 4 days before and 4 days after the crash date. This categorization was also used to identify those not at risk of New SA. The group Ongoing SA/DP were excluded in the logistic regression.

3.3.4.2 *Study II*

In Study II, SA and DP were assessed weekly for a duration of four years, one year before through three years after the week of the crash. The week of the crash, W_0, was defined as the crash date, three days before, and three days after that date (that is, seven days, centered around the date of the visit/hospitalization). Sickness absence and DP for each week were categorized into the following five non overlapping states: 1: no SA or DP (no SA or DP during the week), 2: SA (any SA during the week, and no DP), 3: SA and DP (both SA and DP during the week), 4: part-time DP (any part-time DP, and no SA or full-time DP during the week), and 5: full-time DP (any full-time DP, and no SA during the week).

3.4 STATISTICAL ANALYSES

In Study I, descriptive statistics, including frequencies and percentages, were used to describe the study population in total and stratified by SA and DP status at the time of the crash. Logistic regression was used to estimate odds ratios (OR) and 95% confidence interval (CI) for New SA. In these analyses those with Ongoing SA/DP at the time of the crash were excluded. Crude OR and OR for five different models (including sociodemographic, crash, and injury characteristics) were calculated.

In Study II, descriptive statistics, including frequencies and percentages, were used to describe the study population for all and stratified by sex. Sequences of all individuals' weekly SA/DP states were estimated during a four-year period, from one year before through three years after W_0, with sequence analysis using TraMineR[69] in R. Cluster analyses with optimal matching spell were then used to find different clusters of individuals who had similar sequences of SA/DP-states. The clusters were illustrated in density plots and plots of representative sequences showing the sequence(s) that with a neighborhood radius of 10% cover(s) at least 35% (arbitrarily chosen) of all sequences in each cluster. Crude and mutually adjusted multinomial logistic regressions were used to analyze the association (OR and 95% CI) between sociodemographic, crash, and injury factors, and the different SA/DP-clusters.

3.5 ETHICS

All analyses in this thesis were made on anonymized linked microdata. The project was approved by the Regional Ethical Review Board, Stockholm, Sweden (dnr: 2007/762-31, 2009/23-32, 2009/1917-32, 2011/806-32, 2011/1710-32).

4 RESULTS

The results of the two studies are presented below.

4.1 STUDY I

In total, 7643 individuals aged 16-64 received in- or specialized out-patient healthcare due to a new bicycle crash in 2010. There were similar proportions of individuals in each age group, larger proportions of men (57%), individuals born in Sweden (85%), individuals living in medium-sized cities (42%), not married (68%), and with high school or college/university education (77%). Most of the individuals (72%) did not have any ongoing SA spell >14 days or full-time DP at the time of the crash, nor a new SA spell in connection to the crash. In total 18% had new SA and 10% were already on SA or full-time DP at the time of the crash (Table 3).

Table 3. Numbers and percentages of the study population, by sickness absence (SA) and disability pension (DP) status at the time of the bicycle crash, stratified by sex and age groups. Part of table 1 from Study I[70].

	Total		No new SA		New SA		Ongoing SA/DP	
	n	**column%**	**n**	**row%**	**n**	**row%**	**n**	**row%**
Total (row%)	7643	100.0	5528	72.3	1367	17.9	748	9.8
Sex								
Women	3303	43.2	2293	69.4	678	20.5	332	10.1
Men	4340	56.8	3235	74.5	689	15.9	416	9.6
Age group, years								
16-24	1576	20.6	1461	92.7	74	4.7	41	2.6
25-34	1217	15.9	970	79.7	167	13.7	80	6.6
35-44	1580	20.7	1136	71.9	323	20.4	121	7.7
45-54	1746	22.8	1133	64.9	400	22.9	213	12.2
55-64	1524	19.9	828	54.3	403	26.4	293	19.2

An age-related trend was found with larger proportions of New SA and Ongoing SA/DP with increasing age. As mentioned above, there was a larger proportion of men injured, on the other hand there was a larger proportion of women with new SA, i.e., 20.5% among women, and 15.9% among men (Table 3). Most individuals, 6484 (85%), were injured in a single-bicycle crash and among those 18% had a new SA in connection to the crash. The proportion with a new SA were similar for collision with pedestrian, animal, or other bicycle (19%), and collision with motor vehicle (19%). A majority (83%) had only specialized out-patient healthcare, in this group 14% had new SA. Among those with in-patient healthcare ≤1day (8% of the individuals) 24% had new SA and among those with in-patient healthcare >1 day (9% of the individuals), 51% had new SA in connection to the bicycle crash.

External injuries and fractures were the most common injury types, accounting for 39% and 37% of all injuries, respectively. Although, the injury types with highest proportion of new SA were fractures and dislocations in which 33%, and 24%, had new SA in connection to the crash, respectively (Figure 2). The most commonly injured body regions were the ‘upper extremities' (43%) followed by the 'lower extremities' (19%) and 'head, face, and neck, not TBI' (19%). The injured body regions with largest proportions of New SA in connection to the crash were injuries to the 'spine and back' (37%) (n=156), and 'TBI, not concussion' (36%) (n=117) (Figure 2).

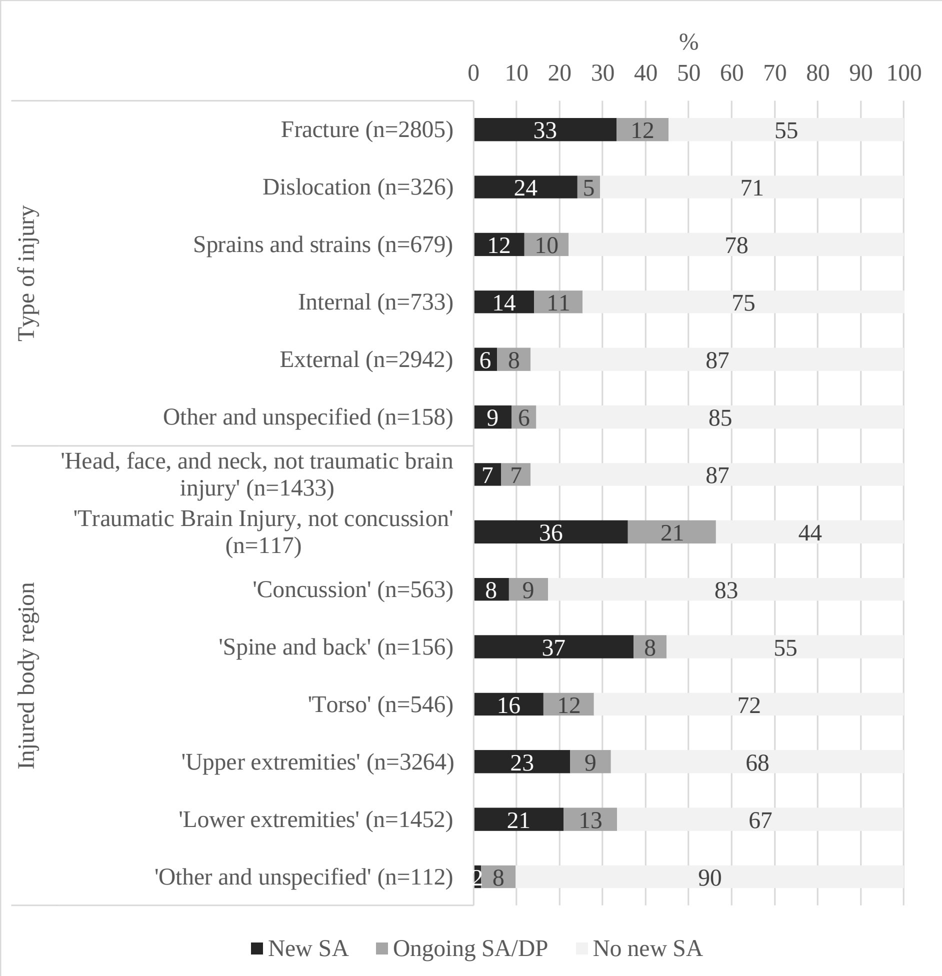

Figure 2. Proportion of individuals with New SA, Ongoing SA/DP, and No new SA, respectively, among those with different types of injury and injured body region.

In the analysis of OR of New SA, those not at risk of new SA (i.e., Ongoing SA/DP) were excluded, leaving 6895 individuals for the analyses. The adjusted OR for a New SA among women compared with men was 1.55 (95% CI 1.34–1.78). The OR for New SA was higher among older individuals. For individuals with high-school education compared with those with university/college education, the OR was 1.77 (95% CI 1.52–2.07). Having had in-patient healthcare >1 day was strongly associated with New SA both crude (OR 8.47; 95% CI 7.04–10.18) and fully adjusted for sociodemographic, crash- and injury-related factors (OR

7.54; 95% CI 6.20–9.17). In addition, higher OR for New SA was observed for collision with motor vehicle compared with single bicycle crashes in the fully adjusted model.

Crude OR and two models with adjusted ORs for type of injury and injured body region are presented in Table 4. In model 4 type of injury and injured body region are separately adjusted for age, sex, level of education, country of birth, type of living area, marital status, and crash type, in model 5 they are further adjusted for each other, i.e. both type of injury and injured body region are included in the same model. When adjusting for sociodemographic factors and crash type (Model 4), the results did not alter substantially from the crude ORs. However, after also mutually adjusting for type of injury and injured body region (model 5), a larger difference can be seen.

Table 4. Crude and adjusted odds ratios with 95% confidence intervals for new sickness absence (SA) following a bicycle crash. Part of table 4 in Study I [70].

	All at risk of SA[1]	Crude	Model 4[2]	Model 5[3]
	n (% SA)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Type of injury				
Fracture	2465 (37.7)	9.60 (8.03-11.48)	9.74 (8.09-11.73)	8.04 (6.62-9.77)
Dislocation	309 (25.6)	5.44 (4.03-7.35)	5.48 (4.00-7.49)	4.36 (3.15-6.05)
Sprains and strains	609 (13.1)	2.40 (1.80-3.18)	2.62 (1.96-3.51)	1.77 (1.31-2.40)
Internal	651 (15.8)	2.98 (2.29-3.88)	3.04 (2.32-3.99)	7.34 (3.67-14.66)
External	2712 (5.9)	ref.	ref.	ref.
Other and unspecified	149 (9.4)	1.64 (0.93-2.91)	1.62 (0.90-2.90)	2.83 (1.51-5.31)
Injured body region				
'Head, face, and neck, not traumatic brain injury'	1335 (7.0)	ref.	ref.	ref.
'Traumatic brain injury, not concussion'	93 (45.2)	11.00 (6.95-17.41)	9.40 (5.81-15.20)	2.72 (1.19-6.22)
'Concussion'	512 (9.0)	1.32 (0.91-1.91)	1.36 (0.93-1.98)	0.38 (0.18-0.83)
'Spine and back'	144 (40.3)	9.01 (6.07-13.36)	9.06 (5.98-13.72)	3.53 (2.24-5.55)
'Torso'	482 (18.5)	3.02 (2.21-4.13)	2.66 (1.93-3.66)	1.48 (1.04-2.11)
'Upper extremities'	2956 (24.8)	4.40 (3.51-5.52)	4.48 (3.55-5.65)	2.09 (1.61-2.70)
'Lower extremities'	1270 (23.9)	4.20 (3.28-5.38)	4.05 (3.14-5.22)	2.81 (2.12-3.72)
'Other and unspecified'	103 (1.9)	0.26 (0.06-1.09)	0.29 (0.07-1.18)	0.29 (0.07-1.29)

[1] N = 6895, i.e. excluding those already on SA or full-time disability pension, among all individuals in Sweden of working ages who in 2010 had a new bicycle crash leading to in- or specialized out-patient healthcare

[2] Adjusted for age, sex, level of education, country of birth, type of living area, marital status, and crash type.

[3] Adjusted for age, sex, level of education, country of birth, type of living area, marital status, crash type, type of injury, and injured body region.

Especially for internal injuries, crude OR and OR in model 4 were about 3, but increased to 7.3 in model 5. For 'TBI, not concussion' and 'Spine and back' the corresponding ORs decreased from 9.4 and 9.1 to about 2.7 and 3.5, respectively. In addition, the OR for New SA following a bicycle crash for 'lower extremities' and 'upper extremities' were 2.81 (95%

CI 2.12-3.72) and 2.09 (95% CI 1.61-2.70) in the fully adjusted model, respectively. Individuals with fractures had in the fully adjusted model eight times higher adjusted OR for New SA compared with individuals with external injuries.

4.2 STUDY II

In Study II, the individuals were followed according to weekly SA and DP states during one year before and through three years after the bicycle crash. In order to include only those eligible to SA or DP the study population was restricted to those aged 18-59. Further, those individuals who died or emigrated during the three years after the bicycle crash were excluded, leaving a study population of 6353 individuals. Seven clusters of sequences of weekly SA and DP states during four years (one year before and through three years after the bicycle crash) were identified with sequence and cluster analyses. The seven clusters were named “No SA or DP” (58.2% of the cohort), “Low SA or DP” (7.4%), “Immediate SA” (20.3%), “Episodic SA” (5.9%), “Long-term SA” (1.7%), “Ongoing part-time DP” (1.7%), and “Ongoing full-time DP” (4.8%). All clusters had different patterns of SA and DP during the four studied years, the representative sequence(s), visualizing these patterns and their homogeneity/heterogeneity are shown in Figure 3. The width of the bars is proportional to the number of sequences in each representative sequence. The scale in the top of each cluster, represent for each representative sequence; A: discrepancy and; B: the mean distance to the representative sequence.

The largest and also most homogenous cluster was “No SA or DP”, containing one representative sequence with only the state no SA or DP during all four years, this sequence covers (with a neighborhood radius of 10%) 100% of the sequences in this cluster. In this cluster 62% were men, 59% were 18-40 years old, 41% had university/college education, 84% were born in Sweden, 38% were living in big cities, 30% were married, 85% were injured in a single bicycle crash, 89% had no inpatient healthcare at the crash date, 47% had external injuries, and 24% had injuries to the ‘head, face, and neck, not TBI’. This cluster, and the here mentioned categories were used as reference groups in the mutually adjusted multinomial logistic regression.

In the cluster “Low SA or DP”, two representative sequences, with only a couple of weeks of SA, during follow-up, represent 50% of the sequences in that cluster.

In the cluster “Immediate SA”, one representative sequence, with SA starting in direct connection to the week of the crash, and ending a couple of months after, represents 80% of the sequences in that cluster.

The cluster “Episodic SA” is a heterogenic cluster with four representative sequences covering 44% of the sequences in that cluster. All four representative sequences start SA in connection to the week of the crash, one had SA for over one year, the other three had a short SA spell starting at the week of the crash but also recurring events of SA later during the follow-up.

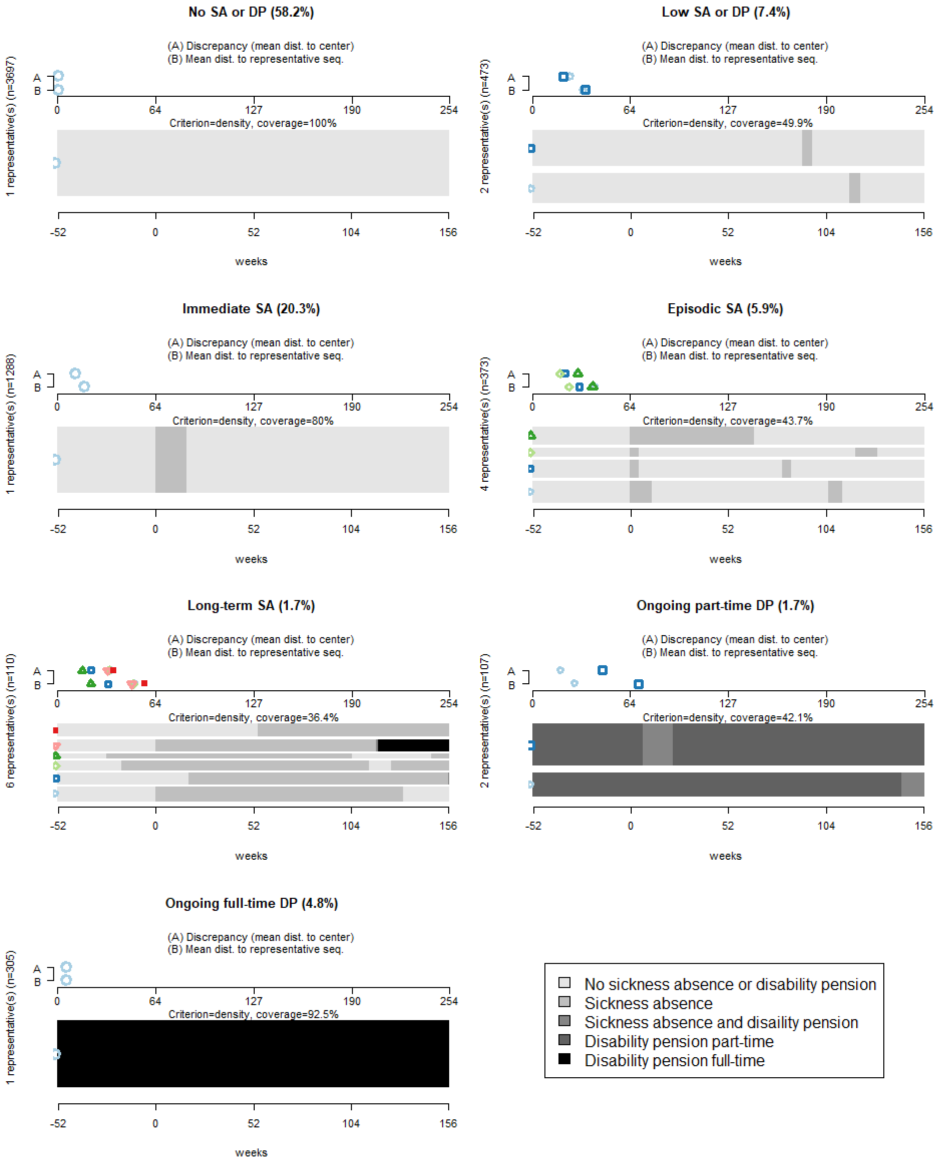

Figure 3. Representative sequence(s) that with a neighborhood radius of 10% cover(s) at least 35% of all sequences of SA and/or DP states/week during one year before through four years after the week of the bicycle crash (marked with 0 in the figure), in each of the seven identified clusters.

The cluster “Long-term SA” is even more heterogenic, here six representative sequences were identified, yet combined they cover only 36% of that cluster. All of these contain long periods of SA, with varying starting points; before the crash, at the crash, and a year after the crash. One of the representative sequences that start SA in connection to the crash transitions to full-time DP after two years, and remained at full-time DP during the rest of the follow-up.

In the cluster “Ongoing part-time DP” the individuals had part-time DP during the whole follow-up, from one year before through three years after the crash, some individuals with part-time DP had combined SA and DP during a couple of months in connection to the crash. These two representative sequences represent 42% of the sequences in that cluster.

In the cluster “Ongoing full-time DP” one representative sequence, with full-time DP during all four years, represents 93% of the sequences in that cluster.

Compared to the cluster “No SA or DP”, all other clusters were associated with higher proportions of women, individuals in the age group 41-59 years, and individuals with high school education. Further, there was a significantly higher proportion with elementary education in the clusters, “Low SA or DP”, “Ongoing part-time DP”, and “Ongoing full-time DP”. All clusters, except “Low SA or DP”, were associated with a higher proportion of inpatient healthcare compared to the cluster “No SA and DP”. The proportions of type of injury in each cluster are shown in Figure 4. External injuries were the most common type of injury in the clusters “No SA or DP”, and “Low SA or DP”, and had its smallest proportion in the cluster “Immediate SA”. Fractures were the most common type of injury in the clusters “Immediate SA” and “Episodic SA”. The largest proportion of internal injuries was in the cluster “Long-term SA”.

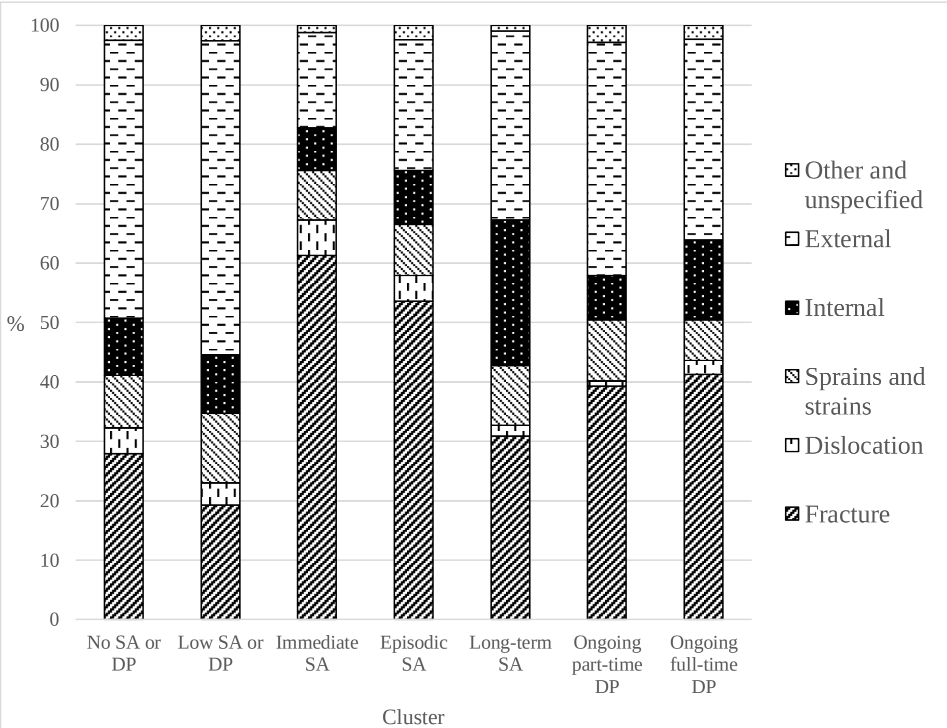

Figure 4. Proportion of type of injuries within each cluster.

The proportions of injured body regions in each cluster are shown in Figure 5. The most frequent injured body region in all of the clusters were ‘upper extremities’, ranging between 34% and 54% of the injuries in the different clusters. The clusters “Low SA or DP”, “Immediate SA”, and “Episodic SA” were associated with higher proportion of injuries to the ‘upper extremities’. The proportion of ‘TBI, not concussion’ was largest in the cluster “Long-term SA” 11%, in the other cluster, this proportion ranged between 0,6% and 2,7%. The OR for ‘TBI, not concussion’ in the cluster “Long-term SA” was 18.4 (95% CI: 2.2-155.2).

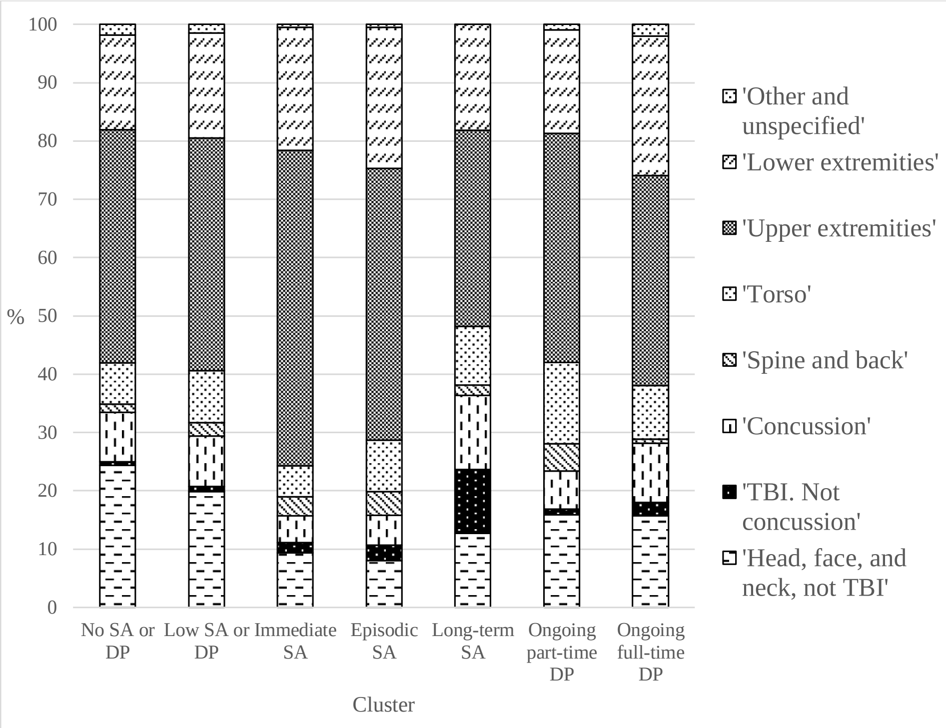

Figure 5. Proportion of injured body regions within each cluster.

5 DISCUSSION

The overall aim of this thesis was to increase the knowledge on SA and DP among individuals of working age injured in a bicycle crash. This was investigated in two studies, below the main findings of these two studies are presented first, followed by a discussion of the results, and last some methodological considerations are presented.

5.1 MAIN FINDINGS

The results of Study I showed that 18% of the individuals of working age who in 2010 had a new bicycle crash leading to in- or specialized out-patient healthcare had a new SA spell >14 (New SA) days in connection to the crash, while 10% already were on SA or on full-time DP (Ongoing SA/DP) at the crash date. Women compared to men, older individuals, and individuals with only high school education had higher ORs for New SA in connection to the crash. Being hospitalized >1 day compared with only out-patient healthcare, having a fracture compared with external injuries, and having a 'TBI, not concussion' injury or a 'spine and back' injury compared with injuries to 'head, face and neck, not TBI' also involved higher ORs for New SA. In Study II, seven different clusters of SA and DP sequences were identified, displaying the diversity in SA and DP patterns in relation to a bicycle crash. The largest cluster, was the cluster named "No SA or DP", with 58% of the individuals, showing that most of the crashes did not lead to SA >14 days. A fifth of the individuals (20%) belonged to the cluster "Immediate SA" with a new SA spell in direct connection to the bicycle crash, and 6% of the individuals belonged to the cluster "Episodic SA" with a somewhat longer SA spell in connection to the crash and/or recurrent SA spells during follow-up. These two clusters were, e.g., associated with high proportions of individuals with fractures and injuries to the 'spine and back' and the 'lower extremities'. The cluster "Long-term SA" consisted of only 2% of the individuals; the individuals in this cluster had long-term SA spells lasting over major parts of the studied period. This cluster was associated with high proportions of individuals with a 'TBI, not concussions' injury and being involved in a collision with a motor vehicle.

5.2 DISCUSSION OF RESULTS

The results of Study I showed that 18% of the individuals with a new bicycle crash leading to in- or specialized out-patient healthcare had new SA in connection to the bicycle crash. In Study II, the individuals in the clusters "Immediate SA", "Episodic SA", and "Long-term SA" together consisted of 28% of the individuals. The larger proportion of SA in Study II compared to Study I, illustrates the importance of not only taking SA in direct connection to the crash into consideration, but also during a long-term perspective. Several of those who in Study I were classified as having Ongoing SA/DP, could have been included in one of the three clusters involving SA in Study II, and likewise some of those without SA in Study I were clustered as with SA or DP in Study II.

Study I showed a higher OR for New SA among women (OR 1.4; 95% CI 1.2-1.6) and higher OR with increased age. This was also seen in all the clusters in Study II. This is in line with previous research on SA in general[52] and can also be seen in one study on bicycle crashes[38] and studies on other road traffic injuries[33, 35]. The higher levels of SA among women and individuals of higher ages injured in a bicycle crash could have several reasons, e.g., injuries such as fractures are more common among women and elderly[71, 72].

Study I showed that among those with in-patient healthcare lasting more than one day, half (51%) had a New SA spell >14 days, and only 14% among those with only specialized out-patient healthcare. Study II confirms the association between inpatient healthcare and SA/DP, where an association between having been hospitalized and the clusters "Immediate SA", "Episodic SA", "Long-term SA", "Ongoing part-time DP", and "Ongoing full-time DP" could be seen. This association has also been shown in previous studies on bicycle crashes[37-39].

The results can be compared to the few previous studies. In a Swedish study with data from 1978-79, 19% of the 447 included individuals had SA[36]. That study included also individuals younger than 16 years of age and older than 64 years of age and hence not applicable for SA, therefore, their results regarding proportion of individuals with SA could have been underestimated. In another Swedish study of 791 patients (whereof 190 were bicyclists) who had in-patient healthcare after a road traffic accident in 1970, 25% had SA for more than four weeks[37]. Those two studies from the 1970's had rather low number of patients who were selected from specific hospitals in Sweden, e.g., the study was not population based. A Finnish study of 542 individuals (of which 264 were aged 15-64) injured in a bicycle crash in 1985-1986 using self-reported information on work disability days (SA+DP), was also a small and rather old study[38]. These three studies investigating SA after a bicycle crash, showed that SA was common following a bicycle crash and stress the need for new and larger studies. A recent study by Ohlin et al.[39] from the same project as the two studies this thesis is based on, investigated the duration of a new SA spell (>14 days) following a bicycle crash using the same type of data as in this thesis, that is, including all individuals with in- or specialized outpatient healthcare due to injuries sustained in a bicycle crash. However, in Ohlin et al.[39] those with ongoing SA or DP were excluded. To get a broader picture of the situation the studies in this thesis also included those with already ongoing SA and DP at the crash. In this way, all patients living in Swedes with injuries sustained in a new bicycle crash could be included, not just those treated at specific hospitals as in the three first mentioned studies[36-38]. Further, in Study II the long-term patterns regarding SA and DP are explored using a comprehensive method, taking each individual's weekly SA and DP state into account.

The Finnish study[38] found that among the hospitalized individuals aged 15-64 (n = 63), those injured in a collision with a motor vehicle had longer self-reported work disability than those hospitalized for other types of bicycle injuries. This may be due to greater crash severity in such collisions. In Study II, this was observed in the cluster "Long-term SA", but not in the other clusters, where other factors were of more importance. The type of crash was not associated with the other clusters and could imply that the single bicycle crashes included in this thesis are as severe as the other types of crashes, and consequently equally important to prevent. The information on number of bicycle crashes, especially single bicycle crashes, are underestimated in many countries as they usually are based on police reports[24, 73, 74]. It is known that hospital data covers a higher proportion of the road traffic crashes than data of police reported crashes[23]. Based on the results from previous studies, which were mainly based on hospital data, most of the crashes are single-bicycle crashes, or bicycle crashes not involving a motor vehicle (70-77%)[1, 24, 36, 38, 75]. In this thesis the proportion of single bicycle crashes was 85%.

This thesis showed that 'upper extremities' are the most commonly injured body region, followed by 'all head and neck' with 43% and 28% of the injuries, respectively. This is in line with previous studies showing upper extremities and/or the head to be the most commonly injured body regions[36, 38, 39, 74, 75]. 'All head and neck' was in most analyses divided into the three groups: 'head, face and neck, not TBI'; 'TBI, not concussion', and 'concussion'. These injuries have different severity levels [76, 77], therefore it is a big advantage to study them separately.

Previously, only Ohlin et al[39], have investigated the risk of SA for the different body regions. That study showed that upper extremities had the highest OR for SA 15-29 days, and for SA 30-89 days. Whereas, spinal injuries followed by TBI, and injuries to the lower extremities had the highest OR for SA $\geq$ 90 days[39]. Study I, also showed that the injured body region with largest proportions of New SA in connection to the crash were injuries to the 'spine and back' (37%) and TBI, not concussion (36%), those body regions each represented only about two percent of the injuries. However, these two groups had a nine- and eleven-fold OR for New SA, respectively, compared with individuals with injuries to the 'head, face and neck, not TBI'. Further, Study II showed that 'TBI, not concussion' had high OR for the cluster "Long-term SA". To prevent these types of injuries is important since long SA spells contribute with a great proportion of SA days[42]. One possible way of effectively preventing TBI could be with the use of a helmet[77].

This thesis found external injuries to be the most common type of injury. External injuries were the injury type with the lowest OR for New SA in Study I and also the most common type of injury in the clusters "No SA or DP" and "Low SA or DP" in Study II. The second most common type of injury was fracture (37%). In Study I, fractures had a ten-fold OR for New SA compared with external injuries. This implies that individuals with the most commonly injured body region or type of injury did not necessarily have the highest ORs for receiving New SA. Also, some of the small groups in type of injuries and injured body regions had higher OR in the clusters "Episodic SA" and "Long-term SA" and therefore contributed with more SA days e.g. 'TBI, not concussion' mentioned above. The contribution of SA days depends on both the number of injured and the sequences of SA and DP following a bicycle crash. In order to prevent the consequences in terms of SA and DP after a bicycle crash it is essential to take both the large numbers of fractures leading to SA and the smaller number of injuries leading to long-term SA into consideration. This is important both in future research and for interventions.

Study II, showed that 66% had no or low SA and DP during the follow-up. This is in line with a smaller Swedish study using group-based trajectory models were 76% of the included 903 individuals with a road traffic injury were found to have a pattern of a low number of SA days during the three-year follow-up[35]. However, that study did not consider DP during the follow-up, nor was the type of road traffic accidents displayed. To obtain a more complete picture of individuals with reduced work capacity due to disease or injury, both SA and DP need to be taken into consideration in order not to underestimate the total number. Moreover, SA may lead to DP and those with full-time DP are not at risk of SA.

The heterogeneity of SA and DP was highlighted in Study II using sequence and cluster analysis where seven different clusters of SA and DP patterns where identified. Some clusters were homogeneous, e.g., "No SA or DP" and "Ongoing full-time DP", whereas others were heterogeneous with several representative sequences of SA and/or DP in the same cluster, e.g., "Episodic SA" and "Long-term SA". Sequence analysis provides a more comprehensive picture of various SA and DP patterns and can be seen as a good complement to traditional regression analysis[47-50].

The heterogeneity seen in the cluster "Long-term SA" could be due to that all individuals with long-term SA spells are clustered into this cluster, not only those with SA due to the bicycle crash, hence the SA spell could have started before or after the crash date. Similar argument can be made in the other clusters, since the SA and DP diagnoses were not taken into consideration. In addition, an injury from a bicycle crash could worsen the situation for the individuals with an already ongoing SA or DP, and for this reason prolong their SA or DP. All SA, regardless of diagnoses, is important to study since a bicycle crash also affects quality of life that could lead to worsened health[13, 78].

Sickness absence and DP were observed among some individuals during the one-year observation period before the bicycle crash in the cluster "Episodic SA" and especially in the cluster "Long-term SA". This could also be seen in two previous studies on road traffic accidents[34, 35]. This illustrates the importance of taking both previous and ongoing SA and DP into consideration in order to not under- or overestimate the effect.

In a recent study by Elrud et al.[34], investigating SA after a car crash, using the same type of data and a similar study design as in Study I, it was found that 9% of the injured car occupants had ongoing SA/DP at the time of the crash. That is, similar proportions regarding ongoing SA and DP as in Study I. However, Elrud et al.[34] observed that 10% among injured car occupants had a new SA spell in connection to the car crash. In Study I, the proportion who had a new SA spell in connection to the bicycle crash was twice as high; 18%. This highlights the importance of reducing bicycle crashes and related injuries. Moreover, to be injured in a bicycle crash can have long-term effects for the individual in terms of SA and

DP. In order to fulfill the Vision zero, which implies that no one should die or suffer injuries that lead to non-acceptable loss of health in the road transport system[17], these bicycle injuries need to be addressed.

5.3 DISCUSSION OF METHODS

The main strength of the studies in this thesis was the use of data from population-based high-quality nationwide administrative registers[26, 27]. This enables the use of large study populations and allows for subgroup analyses. In addition, the rich data made it possible to use comprehensive statistical methods such as sequence analysis. Moreover, both retrospective and prospective data of the crashes were used.

The larger number of observations implies higher precision of the estimates. However, this does not eliminate the risk of bias such as systematic errors due to the omitted variables or missing information. A low degree of bias in a study corresponds to high internal validity. Whereas, the possibility of applying the study to other settings, i.e., the generalizability of the study is referred to as external validity. The selection bias, information bias, confounding and external validity of the performed studies are discussed below in more detail.

5.3.1 Selection bias

Selection bias occurs when the selection of the sample is not properly randomized, e.g., the sample selected from the population does not represent the population. Both studies in this thesis used data from high-quality nationwide registers[26, 27] covering the whole population of all residents of working age in Sweden. This will minimize the selection bias, since all individuals are included, there is no option not to participate. Also, all individuals of working age in Sweden are covered by the public SA and disability benefit insurance scheme. Therefore, there are no groups of individuals with self-selected insurance neither a risk of adverse selection where those with the greatest need had higher coverage rate of sickness insurance than others. The population in Study I and Study II were based on those with in- or specialized out-patient healthcare due to an injury sustained in a bicycle crash, i.e., only those bicycle crashes that were severe enough to acquire such healthcare were included in the study group, hence those only seeking primary healthcare or who did not seek healthcare at all after their bicycle crash were not taken into consideration. In addition, individuals living far from hospitals may possibly seek primary healthcare first, and just seek in- or specialized healthcare if the injury is severe enough. This may underestimate the number of bicycle crashes, especially those resulting in minor injuries. On the other hand, in Sweden most individuals seek healthcare if in need of it as all individuals are covered within the general and public healthcare insurance, implying minimal costs for the individual. This will reduce the selection bias. Previous studies have mainly been based on small samples from emergency units or police data[24, 36-38]. In Sweden as well as in other countries, the number of crashes is often underestimated in police reports[23, 24]. Hence, the use of healthcare data is a strength when studying injuries sustained in bicycle crashes[24, 26, 27].

5.3.2 Information bias

Information bias occurs when the variables (exposure and/or outcome) are misclassified, e.g., measurements error in the information required. Non-random misclassification may lead to under- or overestimation of the estimates and the results may be biased. Whereas random misclassification may lead to dilution of the estimates. The use of high-quality register data reduces the risk of misclassification, and enabled several years of complete follow-up data. Furthermore, the rich data used in the sequence analysis in Study II, allowed for a more complete picture of the heterogeneous SA and DP patterns where several weeks of data were used based on dates on both SA, DP, and in- and specialized out-patient healthcare, i.e., did not classify individuals based on a single point in time.

However, when using register data, information on some relevant variables may be missing or unknown for all or for a subset of the individuals. This latter is the case for the variable crash type in which about a fifth were coded as unspecified accidents. In Study I and II those accidents were grouped as single bicycle crashes as the presumed majority of those were single-bicycle crashes, e.g. those where another bicycle or a vehicle were involved are presumed to more likely be coded as such since there are more individuals involved. Further, the exact date of the crash is not available in hospital data, only the date of in- or specialized out-patient healthcare due to the injuries sustained. Even though the majority of the individuals are likely to seek healthcare right away especially for the more severe injuries, an individual might come to specialized healthcare one or some days after the crash. Reasons for this delay might be not being close to healthcare, due to initially not feeling the need for healthcare, or due to having been to primary healthcare first. In order to only include individuals with new crashes (e.g., not individuals revisiting the healthcare after some time), a wash-out period of three years was used, excluding those with previous visits/hospitalizations due to traffic crashes. To handle the uncertainty regarding the exact crash date, and the fact that some individuals started their SA some days before or after their healthcare visit/hospitalization (e.g., did not seek specialized healthcare until a couple of days after the bicycle crash - or they might have waited to report the SA spell, e.g., due to the crash happening during a weekend or holiday). New SA in connection to the crash was in Study I defined as SA spells starting ±4 days of the first healthcare visit/hospitalization. This was decided based on the distribution of the start dates of SA spells, as a substantially higher proportion of new SA spells was seen during this time-window. Similarly, in Study II, weekly data was used and the week of the crash (W_0) was defined as the date of the healthcare visit/hospitalization ±3 days.

The variables: type of injury and injured body region were categories using diagnoses from The National Patient Registers with high coverage of the diagnoses for inpatient healthcare 99% and for specialized outpatient healthcare 98% of the visits have diagnoses[64]. The majority (78%) only had one injury diagnosis registered on the date of the crash, for the others a selection of only one injury diagnosis was made, this might have led to information bias e.g. over- or under-estimation of different injury diagnoses. Also, the variables: type of injury and injured body region had about 2% with “other or unspecified” diagnoses.

Only information on SA spells >14 days was available. The use of this register-based information can be viewed as both a limitation and a strength. A strength, as all SA is verified by a physician, this will reduce the misclassification compared to e.g. self-reported SA, and hence limit the information bias. A limitation, as there for most individuals is no information on SA spell <14 days, and most SA spells are short-term. In Sweden, about three quarters of all SA spells are shorter than 7 days, and only about 2% are longer than 90 days. However, spells longer than 90 days contribute to about half of all SA days in total[42, 43].

5.3.3 Confounding

A confounding factor is associated with both exposure and the outcome and is not a step in the causal pathway between the exposure and the outcome, not controlling for a confounder might under- or overestimate the true effect. The use of microdata from several nationwide registers and with large study-population, made sub-group analyses possible, with more clusters and categorizations, and to include several potential confounders in the analyses. The results in the thesis were controlled for sociodemographic factors (sex, age, level of education, country of birth, type of living area, and marital status), type of specialized healthcare (inpatient or specialized outpatient), and crash related factors (crash type, type of injury, and injured body region). However, there might be residual confounding for unmeasured factors such as helmet use, time of the day, and type of traffic environment, as information on these were not available.

5.3.4 External validity

External validity refers to the generalizability of the findings from one study to another population, e.g., general population, other countries, or a more specified target population. Both studies were based on the population of Sweden of working age, receiving in- or specialized outpatient health care due to injuries sustained in a bicycle crash. Thus, the results are directly applicable to the general population of working age in Sweden and probably to other countries with extensive welfare systems. However, to compare countries, aspects of social and health insurance system, labour market participation etc. need to be considered.

6 CONCLUSIONS

- The majority of those injured in a bicycle crash did not have SA or DP in connection to the crash, nor during three years after the crash. However, a substantial proportion, about a fifth of the injured started a new SA spell in connection to the crash.

- Sequence analysis proved to be a good method to capture and illustrate the heterogeneity of SA and DP. In total seven clusters of different patterns of SA and DP after a bicycle crash were identified and the heterogeneity in patterns of SA and DP was clearly visualized. Two of the identified clusters had no or very little SA and DP during the follow-up, three clusters had different levels of SA, and the other two had DP of different extent.

- In general, the type of crash was not associated with SA and DP following a bicycle crash except for a higher proportion bicyclists injured in collisions with motor vehicles within the cluster “Long-term SA”. The majority of the cyclists were injured in a single bicycle crash which implies that the single bicycle crashes are as important as the other types of crashes to prevent.

- The injury type affected the SA and DP following a crash. Individuals with fractures were more frequent among the clusters with shorter SA spells. Whereas, ‘TBI, not concussion’ had higher risk for long-term SA spells.

- To understand the negative long-term impacts of bicycle injuries this thesis presents a new perspective by studying SA and DP after a bicycle crash. However, it is important to take previous or ongoing SA or DP into consideration when studying SA and DP following a crash. In total a tenth of the individuals had already ongoing SA or full-time DP at the time of the crash. Most of those with DP (part- or full-time) had that during the whole study period (one year before through three years after the crash).

7 FUTURE RESEARCH SUGGESTIONS

The research on SA and DP among injured bicyclists is very scarce, further research is needed in order to get a more comprehensive as well as deepened understanding of the SA/DP-situation among individuals injured in a bicycle crash. Some aspects that need to be taken into consideration in future research to gain more knowledge are listed below.

- Include information on already ongoing SA and DP at the time of the crash, and preferably also on previous SA and DP.
- Include information on SA and DP diagnoses to get a better understanding of the SA and DP and possibly to what extent the SA and DP are related to the bicycle crash or due to other causes.
- Include also additional information about the crash in the analyses, e.g., traffic environment, and individual factors such as helmet use, whether alcohol and drugs were consumed, previous healthcare, and prescribed drug use.
- To also include the individuals who had primary health care in connection to the bicycle crash could give a better understanding of the problem.
- Include different road-user groups, e.g., bicyclists, car occupants, and pedestrians to make it possible to compare impact of the different factors between the groups and to get a broader understanding of the consequences in terms of SA and DP in the different road-user groups.
- Match those injured, with references from the general population or other road user groups or specific diagnoses in order to gain knowledge on whether SA and DP patterns varies between the different groups, and to increase the comparability between the groups regarding the matching factors.
- Compare data from several years in order to find trends or effect of different injury prevention interventions and other changes, e.g., rule changes and traffic safety improvements.

8 ACKNOWLEDGEMENTS

This thesis was conducted at Karolinska Institutet (Division of Insurance Medicine) in collaboration with Folksam (Traffic safety research group) and was financially supported by Skyltfonden at the Swedish Transport Administration and the Swedish Research Council for Health, Working Life and Welfare.

Thanks to all of you who have followed me on this journey. In particular, a big thank you to:

My main supervisor Emilie Friberg, for your encouragement, for your knowledge, for your support, for everything! To have you as a superhero/supervisor is an honour and a privilege.

My co-supervisor Helena Stigson, for introducing and including me with open arms to traffic safety research and for sharing your knowledge and broaden my horizons within this field.

My co-supervisor Kristina Alexanderson, for including me into the Divisions of Insurance Medicine, first as statistician and then also as a licentiate student. Thank you for sharing your extensive knowledge of the field and for all your support and valuable feedback.

The traffic safety research group at Folksam for the inspiring collaboration.

The project group colleagues and co-authors Maria Ohlin and Rasmus Elrud, for sharing this learning experience and for valuable discussions.

My mentor Anna Löfgren-Wilteus for your positive energy, our fruitful conversations and your good advices.

The opponents at my manus seminars Björg Helgadottir, Domitilla Di Thiene, Magnus Larsson, Mirkka Söderman, and the “kappa” seminar Beatix Algurén. Thank you all for taking your time and for all your valuable feedback.

All my former and present colleagues at the Division of Insurance Medicine. You have all contributed in brightening and enlightening my journey.

Thank you Ellenor Mittendorfer-Rutz, Head of the Division, for your support.

Thanks to my fellow statisticians: Kerstin Nilsson, Pontus Josefsson, Mahbuba Haque and Nils Larsson. Especially to Elin Hinas, without you this journey would not have started.

Thanks to my PhD-fellows: Chantelle Murley, Muhammed Ridwanul Amin, Mirkka Söderman, Rasmus Elrud, and Julio César Hernando.

Thanks to Kristin Farrants for interesting discussions at the Division’s journal clubs as well as in the corridors.

Also, thanks to Annika Evolahti and Katarina Lönnqvist for all administrative support, and to Annika for language review of this thesis.

My colleagues at Sveriges Lantbruksuniversitet (SLU) for the opportunity to teach math and statistics in a welcoming atmosphere.

Tack alla mina vänner, särskilt Yovana, Sara, Joanna och Lena, för att ni följt med under resan och stöttat och inspirerat.

Tack mina föräldrar Eva och Jörgen, för att ni alltid finns där för mig och min familj.

Tack mina systrar Ellen och Karin, för att ni är de bästa systrar man kan tänka sig.

Peter tack för allt du gör för mig, för ditt stöd och din support, för att du ställer upp för mig och tror på mig. Jag älskar dig av hela mitt hjärta.

Konrad och Tekla, underbara fantastiska ni, som ger mig perspektiv på vad som är viktigt här i livet. Ni betyder allt för mig. Jag älskar er!

9 REFERENCES

1. Safer cycling - a common strategy for the period 2014-2020. Swedish Transport Administration; 2014.

2. Transforming our world: The 2030 agenda for sustainable development. United Nations; 2015.

3. Improving global road safety The General Assembly of the United Nations 2010.

4. Saving lives beyond 2020: The next steps. The academic expert group for the third ministerial conference on Global Road Safety 2020; 2019.

5. Stockholm Declaration Third Global Ministrerial Conference on Road Safety: Achiving Global Goals 2030. Stockholm; 2020.

6. Spolander K: Resultat av arbetet för ökad och säkrare cykling samt förslag till forskning, utveckling och innovation. Stockholm; 2013.

7. Ainsworth BE, Macera CA: physical activity and public health practice; 2012.

8. de Hartog J, Boogaard H, Nijland H, Hoek G: Do the health benefits of cycling outweigh the risks? Environ Health Perspect 2010, 118(8):1109-1116.

9. Rojas-Rueda D, de Nazelle A, Teixido O, Nieuwenhuijsen MJ: Health impact assessment of increasing public transport and cycling use in Barcelona: a morbidity and burden of disease approach. Prev Med 2013, 57(5):573-579.

10. Holm AL, Glumer C, Diderichsen F: Health Impact Assessment of increased cycling to place of work or education in Copenhagen. BMJ Open 2012, 2(4).

11. Peden M: World report on road traffic injury prevention. Geneva: World Health Organisation; 2004.

12. Nilsson P, Ohlin M, Stigson H, Strandroth J: Modelling the effect on injuries and fatalities when changing mode of transport from car to bicycle. Accident Analysis and Prevention 2016, 100:30-36.

13. Toft AM, Moller H, Laursen B: The years after an injury: long-term consequences of injury on self-rated health. J Trauma 2010, 69(1):26-30.

14. Nollvisionen och det trafiksäkra samhället. Swedish Goverment; 1997.

15. Committee report 1997/98:TU4. Stickholm, Sweden: Swedish Parliament; 1997.

16. På väg mot det trafiksäkra samhället. Stockholm, Sweden: Swedish Goverment; 1997.

17. Tingvall C: The zero vision - A road transport system free from serious health losses. Transportation, Traffic Safety and Health 1997:37-57.

18. Analysis of Road Safety Trends 2016 – Management by objectives for road safety work towards the 2020 interim targets., vol. 098. Swedish Transport Administration; 2017.

19. Traffic Safety Basic Facts 2018 - Cyclists. European Commission; 2019.

20. En nationell cykelstrategi för ökad och säker cykling – som bidrar till ett hållbart samhälle med hög livskvalitet i hela landet. Government Offices of Sweden; 2017.

21. Gemensam inriktning för säker trafik med cykel och moped 2018. The Swedish Transport Administration; 2018.

22. Amoros E, Martin JL, Chiron M, Laumon B: Road crash casualties: Characteristics of police injury severity misclassification. J Trauma 2007, 62(2):482-490.

23. Amoros E, Martin JL, Laumon B: Under-reporting of road crash casualties in France. Accident; analysis and prevention 2006, 38(4):627-635.

24. Rizzi M, Stigson H, Krafft M: Cyclist Injuries Leading to Permanent Medical Impairment in Sweden and the Effect of Bicycle Helmets. In: IRCOBI Conference: 2013; Gothenburg, Sweden; 2013.

25. Reporting on serious road traffic casualties: Combining and using different data sources to improve understanding of non-fatal road traffic crashes. International Traffic Safety Data and Analysis Group (IRTAD); 2011.

26. Ludvigsson JF, Andersson E, Ekbom A, Feychting M, Kim JL, Reuterwall C, Heurgren M, Olausson PO: External review and validation of the Swedish national inpatient register. BMC Public Health 2011, 11:450.

27. Ludvigsson JF, Almqvist C, Bonamy AK, Ljung R, Michaelsson K, Neovius M, Stephansson O, Ye W: Registers of the Swedish total population and their use in medical research. Eur J Epidemiol 2016, 31(2):125-136.

28. The Swedish Health Care System.

29. Patient Fees & High-Cost Protection [https://www.thenewbieguide.se/health/costs-fees/patient-fees/]

30. Marmot M, Feeney A, Shipley M, North F, Syme SL: Sickness absence as a measure of health status and functioning: from the UK Whitehall II study. J Epidemiol Community Health 1995, 49(2):124-130.

31. Alexanderson K, Norlund A: Swedish Council on Technology Assessment in Health Care (SBU). Chapter 1. Aim, background, key concepts, regulations, and current statistics. Scand J Public Health Suppl 2004, 63:12-30.

32. Vingard E, Alexanderson K, Norlund A: Swedish Council on Technology Assessment in Health Care (SBU). Chapter 9. Consequences of being on sick leave. Scand J Public Health Suppl 2004, 63:207-215.

33. Berecki-Gisolf J, Collie A, McClure R: Work disability after road traffic injury in a mixed population with and without hospitalisation. Accident; analysis and prevention 2013, 51:129-134.

34. Elrud R, Stigson H, Ohlin M, Alexanderson K, Kjeldgård L, Friberg E: Sickness Absence among Passenger Car Occupants following a Crash. In: IRCOBI Conference: 2017; Antwerp, Belgium; 2017.

35. Rissanen R, Liang Y, Moeller J, Nevriana A, Berg HY, Hasselberg M: Trajectories of sickness absence after road traffic injury: a Swedish register-based cohort study. BMJ Open 2019, 9(7):e031132.

36. Bjornstig U, Naslund K: Pedal cycling accidents - mechanisms and consequences. A study from northern Sweden. Acta chirurgica Scandinavica 1984, 150(5):353-359.

37. Hansson PG: Sick-leave after road traffic accidents. Scand J Soc Med 1976, 4(2):103-107.

38. Olkkonen S, Lahdenranta U, Slatis P, Honkanen R: Bicycle accidents often cause disability - an analysis of medical and social consequences of nonfatal bicycle accidents. Scand J Soc Med 1993, 21(2):98-106.

39. Ohlin M, Kjeldgård L, Elrud R, Stigson H, Alexanderson K, Friberg E: Duration of sickness absence following a bicycle crash, by injury type and injured body region: A nationwide register-based study. Journal of Transport & Health 2018, 9:275-281.

40. Hensing G, Alexanderson K, Allebeck P, Bjurulf P: How to measure sickness absence? Literature review and suggestion of five basic measures. Scandinavian Journal of Social Medicine 1998, 26(2):133-145.

41. Hensing G: Swedish Council on Technology Assessment in Health Care (SBU). Chapter 4. Methodological aspects in sickness-absence research. Scand J Public Health Suppl 2004, 63:44-48.

42. Kjeldgård L, Ekmer A, Vaez M, Alexanderson K: Sjukfrånvaro bland kvinnor och män inom polismyndigheten i Stockholms län. Stockholm, Sweden: Karolinska Institutet; 2010.

43. Riksförsäkringsverket: Försäkringsmedicin - allmän försäkring. Stockholm: Försäkringskasseförbundet; 1988.

44. Kvillemo P, Mittendorfer-Rutz E, Branstrom R, Nilsson K, Alexanderson K: Sickness Absence and Disability Pension After Breast Cancer Diagnosis: A 5-Year Nationwide Cohort Study. J Clin Oncol 2017, 35(18):2044-2052.

45. Zetterstrom K, Voss M, Alexanderson K, Ivert T, Pehrsson K, Hammar N, Vaez M: Prevalence of all-cause and diagnosis-specific disability pension at the time of first coronary revascularisation: a population-based Swedish cross-sectional study. PLoS One 2015, 10(1):e0115540.

46. Aisenbrey S, Fasang AE: New Life for Old Ideas: The "Second Wave" of Sequence Analysis Bringing the "Course" Back Into the Life Course. Sociol Method Res 2010, 38(3):420-462.

47. Madsen AA: Return to work after first incidence of long-term sickness absence: A 10-year prospective follow-up study identifying labour-market trajectories using sequence analysis. Scand J Public Health 2019:1403494818821003.

48. McLeod CB, Reiff E, Maas E, Bultmann U: Identifying return-to-work trajectories using sequence analysis in a cohort of workers with work-related musculoskeletal disorders. Scand J Work Environ Health 2018, 44(2):147-155.

49. Lindholdt L, Labriola M, Nielsen CV, Horsbol TA, Lund T: Sequence analysis to assess labour market participation following vocational rehabilitation: an observational study among patients sick-listed with low back pain from a randomised clinical trial in Denmark. BMJ Open 2017, 7(7):e015661.

50. Sabbath EL, Guevara IM, Glymour MM, Berkman LF: Use of Life Course Work-Family Profiles to Predict Mortality Risk Among US Women. Am J Public Health 2015, 105(4):E96-E102.

51. Social Insurance in Figures 2016. Swedish Social Insurance Agency; 2016.

52. Allebeck P, Mastekaasa A: Swedish Council on Technology Assessment in Health Care (SBU). Chapter 5. Risk factors for sick leave - general studies. Scand J Public Health Suppl 2004, 63:49-108.

53. Allebeck P, Mastekaasa A: Swedish Council on Technology Assessment in Health Care (SBU). Chapter 3. Causes of sickness absence: research approaches and explanatory models. Scand J Public Health Suppl 2004, 63:36-43.

54. Jansson C, Mittendorfer-Rutz E, Alexanderson K: Sickness absence because of musculoskeletal diagnoses and risk of all-cause and cause-specific mortality: a nationwide Swedish cohort study. Pain 2012, 153(5):998-1005.

55. Wang M, Alexanderson K, Runeson B, Head J, Melchior M, Perski A, Mittendorfer-Rutz E: Are all-cause and diagnosis-specific sickness absence, and sick-leave duration risk indicators for suicidal behaviour? A nationwide register-based cohort study of 4.9 million inhabitants of Sweden. Occup Environ Med 2014, 71(1):12-20.

56. Sumanen H, Pietilainen O, Lahti J, Lahelma E, Rahkonen O: Interrelationships between education, occupational class and income as determinants of sickness absence among young employees in 2002-2007 and 2008-2013. BMC Public Health 2015, 15:332.

57. Karlsson NE, Carstensen JM, Gjesdal S, Alexanderson KA: Risk factors for disability pension in a population-based cohort of men and women on long-term sick leave in Sweden. Eur J Public Health 2008, 18(3):224-231.

58. Mittendorfer-Rutz E, Harkanen T, Tiihonen J, Haukka J: Association of socio-demographic factors, sick-leave and health care patterns with the risk of being granted a disability pension among psychiatric outpatients with depression. PLoS One 2014, 9(6):e99869.

59. Laaksonen M, He L, Pitkaniemi J: The durations of past sickness absences predict future absence episodes. J Occup Environ Med 2013, 55(1):87-92.

60. Roelen CA, Koopmans PC, Schreuder JA, Anema JR, van der Beek AJ: The history of registered sickness absence predicts future sickness absence. Occup Med (Lond) 2011, 61(2):96-101.

61. Alexanderson K: A structure for categorisation of studies of sickness absence/disability pension. Division of Insurence Medicine: Karolinska Institutet; 2018.

62. Ludvigsson JF, Otterblad-Olausson P, Pettersson BU, Ekbom A: The Swedish personal identity number: possibilities and pitfalls in healthcare and medical research. Eur J Epidemiol 2009, 24(11):659-667.

63. Longitudinell Integrationsdatabas för Sjukförsäkrings- och Arbetsmarknadsstudier (LISA) 1990-2013. Örebro, Sweden; 2016.

64. Forsberg L, Rydh H, Björkenstam E, Anders Jacobsson A, Nyqvist K, Heurgren M: Kvalitet och innehåll i patientregistret. Utskrivningar från slutenvården 1964–2007 och besök i specialiserad öppenvård (exklusive primärvårdsbesök) 1997–2007. Sweden: Socialstyrelsen; 2009.

65. International statistical classification of diseases and related health problems - Systematic listing, Swedish version 2011 (ICD-10-SE). The National Board of Health and Welfare; 2010.

66. World Health Organization: International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10). Geneva; 1993.

67. Dödsorsaker 2014. The National Board of Health and Welfare; 2015.

68. Barell V, Aharonson-Daniel L, Fingerhut LA, Mackenzie EJ, Ziv A, Boyko V, Abargel A, Avitzour M, Heruti R: An introduction to the Barell body region by nature of injury diagnosis matrix. Inj Prev 2002, 8(2):91-96.

69. Gabadinho A, Ritschard G, Muller NS, Studer M: Analyzing and Visualizing State Sequences in R with TraMineR. J Stat Softw 2011, 40(4):1-37.

70. Kjeldgård L, Ohlin M, Elrud R, Stigson H, Alexanderson K, Friberg E: Bicycle crashes and sickness absence - a population-based Swedish register study of all individuals of working ages. BMC Public Health 2019, 19(1):943.

71. Gustafsson M, Stigson H, Krafft M, Kullgren A: Risk of permanent medical impairment (RPMI) in car crashes correlated to age and gender. Traffic Inj Prev 2015, 16(4):353-361.

72. Kanis J: Assessment of Osteoporosis at the Primary Health Care Level. Sheffield, UK: University of Sheffield; 2007.

73. Veisten K, Saelensminde K, Alvaer K, Bjornskau T, Elvik R, Schistad T, Ytterstad B: Total costs of bicycle injuries in Norway: correcting injury figures and indicating data needs. Accident; analysis and prevention 2007, 39(6):1162-1169.

74. Juhra C, Wieskotter B, Chu K, Trost L, Weiss U, Messerschmidt M, Malczyk A, Heckwolf M, Raschke M: Bicycle accidents - do we only see the tip of the iceberg? A prospective multi-centre study in a large German city combining medical and police data. Injury 2012, 43(12):2026-2034.

75. Stutts JC, Hunter WW: Motor vehicle and roadway factors in pedestrian and bicyclist injuries: an examination based on emergency department data. Accident; analysis and prevention 1999, 31(5):505-514.

76. Malm S, Krafft M, Kullgren A, Ydenius A, Tingvall C: Risk of permanent medical impairment (RPMI) in road traffic accidents. Ann Adv Automot Med 2008, 52:93-100.

77. Olivier J, Creighton P: Bicycle injuries and helmet use: a systematic review and meta-analysis. Int J Epidemiol 2017, 46(1):372.

78. Ohlin M, Berg H-Y, Lie A, Algurén B: Long-term problems influencing health-related quality of life after road traffic injury - Differences between bicyclists and car occupants. Journal of Transport & Health 2016, 4:180-190.